IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:
Larry C. Olsen et al.
Application No. 10/726,744
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Confirmation No. 6833
For: THERMOELECTRIC DEVICES AND APPLICATIONS FOR THE SAME
Examiner: Jeffrey Thomas Barton
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AMENDMENT FILED WITH RCE

This responds to the Office action dated April 13, 2009. Please amend the referenced application as follows:

Amendments to the Claims are reflected in the listing of claims, which begins on page 2.

Remarks begin on page 7.

Claims

1. (Currently amended) A thermoelectric power source comprising:

a flexible substrate having an upper surface; and

a plurality of thermoelectric couples with the thermoelectric couples comprising:

(a) a ~~sputter deposited~~ thin film p-type thermoelement positioned on the upper surface of the flexible substrate;

(b) a ~~sputter deposited~~ thin film n-type thermoelement positioned on the upper surface of the flexible substrate adjacent the p-type thermoelement;

(c) an electrically conductive member positioned on the flexible substrate, and electrically connecting the first end of the p-type thermoelement with the second end of the n-type thermoelement, wherein the p-type or the n-type thermoelements comprise Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y wherein ~~x and y form greater than in incidental amount of a non-stoichiometric compound and~~ x is about 2 and y is about 3; ~~and~~

wherein the thermoelectric couples are formed on a single substrate and the flexible substrate is in a coil configuration or an accordion configuration; and

wherein the p-type or the n-type thermoelements have L/A ratios from about 500 cm^{-1} to about 10,000 cm^{-1}.

2. (Withdrawn) A thermoelectric power source comprising:

a flexible substrate having an upper surface; and

a plurality of thermoelectric couples with the thermoelectric couples comprising:

(a) a sputter deposited thin film p-type thermoelement positioned on the upper surface of the flexible substrate;

(b) a sputter deposited thin film n-type thermoelement positioned on the upper surface of the flexible substrate adjacent the p-type thermoelement;

(c) an electrically conductive member positioned on the flexible substrate, and electrically connecting the first end of the p-type thermoelement with the second end of the n-type thermoelement, wherein the p-type or the n-type thermoelements comprise Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y wherein and x is about 2 and y is about 3;

wherein the thermoelectric couples are formed on a single substrate and the flexible substrate is in a coil configuration or an accordion configuration; and

wherein the p-type or the n-type thermoelements have L/A ratios from about 500 cm^{-1} to about 10,000 cm^{-1}.

3. (Currently amended) The thermoelectric power source of claim 1 wherein the p-type ~~or~~ and the n-type thermoelements comprise Bi_xTe_y, Sb_xTe_y, and Bi_xSe_y, wherein x is about 2 and y is about 3 ~~have L/A ratios greater than about 1000 cm^{-1}~~.

4. (Canceled)

5. (Currently amended) The thermoelectric power source of claim 1 wherein the thermoelectric power source has a power output of ~~at least about 1 μW with a voltage of at least about 0.25 volt~~ from 50 μW to 1 W.

6. (Previously presented) The thermoelectric power source of claim 1 further comprising at least about 50 thermoelectric couples, wherein the thermoelectric power source has a power output of at least about 1 μW with a voltage of at least about 0.25 volt.

7. (Original) The thermoelectric power source of claim 6 wherein the p-type or the n-type thermoelements are at least about 1 mm in length and at least about 0.1 mm in width.

8. (Currently amended) The thermoelectric power source of claim 6 wherein the p-type or the n-type thermoelements are at least about 0.1 mm ~~20 angstroms~~ in thickness.

9. (Original) The thermoelectric power source of claim 1 further comprising at least about 1000 thermoelectric couples, wherein the thermoelectric power source has a power output of about 1W with a voltage of at least about 1 volt.

10. (Previously presented) The thermoelectric power source of claim 1 wherein the p-type thermoelements each have a first width, the n-type thermoelements each have a second width, and the first width is different from the second width.

11. (Original) The thermoelectric power source of claim 1 wherein two or more p-type thermoelements are positioned and electrically connected in parallel with one another and the parallel positioned p-type thermoelements are electrically connected in series to n-type thermoelements.

12. (Currently amended) The thermoelectric power source of claim 1 wherein the thin film p-type thermoelements or the thin film n-type thermoelements ~~are co-sputter deposited thin films comprising~~ comprise Bi_xTe_y and Sb_xTe_y, or Bi_xTe_y and Bi_xSe_y.

13. (Original) The thermoelectric power source of claim 1 wherein the volume of the thermoelectric power source is less than about 10 cm^3 and has a power output of from about 1 μW to about 1 W.

14. (Original) The thermoelectric power source of claim 1 wherein the volume of the thermoelectric power source is less than about 10 cm^3 and provides voltages of greater than about 1 volt.

15. (Original) The thermoelectric power source of claim 14 wherein the thermoelectric power source produces power at temperature differences of about 20°C or less.

16. (Original) The thermoelectric power source of claim 1 wherein two or more n-type thermoelements are positioned and electrically connected in parallel with one another and the parallel positioned n-type thermoelements are electrically connected in series to p-type thermoelements.

17. (Currently amended) The thermoelectric power source of claim 1 wherein the n-type or the p-type thermoelements comprise Sb_xTe_y, Bi_xTe_y and Sb_xTe_y, or Sb_xTe_y and Bi_xSe_y ~~are substantially free of selenium~~.

18. (Currently amended) The thermoelectric power source of claim 1 wherein the n-type or the p-type thermoelements comprise Bi_xTe_y and Sb_xTe_y ~~the flexible substrate is a polyimide~~.

Claims 19 – 22 (Canceled)

23. (Withdrawn) A thermoelectric power source comprising:

multiple thermocouples electrically connected to one another on an upper surface of a-single flexible substrate, the thermocouples comprising:

sputter deposited thin film p-type thermoelements having thicknesses of 0.1 mm or greater;

sputter deposited thin film n-type thermoelements alternatingly positioned adjacent the p-type thermoelements, the n-type thermoelements having a thickness of about 0.1 mm or greater;

wherein the thermoelectric power source has a volume of less than about 10 cm^3 and has a power output of from about 1 μW to about 1 W generated by the thermocouples on the-single flexible substrate; and

wherein the p-type thermoelements or the n-type thermoelements comprise a Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y alloy where x is about 2 and y is about 3.

24. (Withdrawn) The thermoelectric device of claim 23 wherein said multiple thermocouples electrically connected to one another are in series-parallel.

25. (Withdrawn) The thermoelectric power source of claim 23 wherein the p-type thermoelements have L/A ratios greater than about 500 cm^{-1}.

Claims 26 – 36 (Canceled)

37. (Currently amended) A thermoelectric power source comprising:

a flexible substrate having an upper surface; and

a thermoelectric couple comprising:

(a) ~~co-sputter deposited~~ alternating thin film p-type and n-type thermoelements positioned on the upper surface of the flexible substrate;

(b) an electrically conductive member positioned on the flexible substrate, and electrically connecting a first end of the p-type thermoelement with-a second end of the n-type thermoelement, wherein the p-type or the n-type thermoelements comprise Sb_xTe_y or Bi_xSe_y wherein x is about 2 and y is about 3; and

(c) wherein the flexible substrate is in a coil configuration.

38. (Previously presented) The thermoelectric power source of claim 37 wherein the p-type thermoelements or the n-type thermoelements are at least about 1 mm in length and at least about 0.1 mm in width.

39. (Previously presented) The thermoelectric power source of claim 37 wherein the volume of the thermoelectric power source is less than about 10 cm^3 and has a power output of from about 1μW to about 1W.

Remarks

By entry of this Amendment, claims 1-3, 5-18, 23-25, 37-39 are pending. Reconsideration is respectfully requested.

Restriction Requirement

Applicants elected Group I, claims 1, 3, 5-18, and 37-39. The withdrawn claims remain in the pending application.

35 U.S.C. § 112 Rejections

The Examiner has rejected claims 1, 3 and 5-18, under 35 U.S.C. § 112, first paragraph, as allegedly failing to comply with the written description requirement. While Applicants disagree, the amendment of claim 1 makes this rejection moot.

The Examiner has rejected claims 1, 3 and 5-18, under 35 U.S.C. § 112, second paragraph, as allegedly being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Again, while Applicants disagree, the amendment of claim 1 makes this rejection moot.

35 U.S.C. § 103 Rejections

The Examiner has rejected claims 1, 3, 5-10, 12-15, 17, 18, and 37-39, under 35 U.S.C. § 103(a) as allegedly being unpatentable over Migowski (WO 89/07836) in view of Böttner ("Thermoelectric Micro Devices: Current State, Recent Developments and Future Aspects for Technological Progress and Applications," Proc. 21st Int. Conf. Thermoelectronics, Long Beach, CA, 25-29 August 2002, pp. 511-518). Applicants traverse.

Claim 1: As amended, claim 1 recites, in part, a thermoelectric power source comprising a flexible substrate, a plurality of thermoelectric couples comprising a thin film p-type thermoelement and a thin film n-type thermoelement formed on the substrate, wherein the p-type or the n-type thermoelements comprise Bi_xTe_y, Sb_xTe_y, or Bi_xSe_y, wherein x is about 2 and y is about 3, and wherein the p-type or the n-type thermoelements have L/A ratios from about 500 cm^{-1} to about 10,000 cm^{-1}.

A. Because certain of the elements of the recited process is not taught or suggested by the art of record, a *prima facie* case of obviousness is not present.

As noted by the Examiner, Migowski suggests an L/A ratio of 15,000 cm^{-1}. This L/A ratio is far outside the recited claim 1 range. The Böttner[1] reference clearly does not make up for this deficiency (nor does the Examiner assert such). Thus, no *prima facie* case of obviousness has been presented.

As the Examiner knows, to support a *prima facie* case of obviousness all of the elements of the recited process must be taught or suggested. A January 2008 Board of Patent Appeals and Interferences decision entitled *In re Wada and Murphy* reversed a § 103 rejection because the Examiner did not explain where or how cited art taught or suggested all of the features of a claimed invention. Of particular interest is the following BPAI articulation of applicable law:

> When determining whether a claim is obvious, an examiner must make "a searching comparison of the claimed invention - including all its limitations - with the teaching of the prior art." *In re Ochiai*, 71 F.3d 1565, 1572 (Fed. Cir. 1995). Thus, "obviousness requires a suggestion of all limitations in a claim." *CFMT, Inc. v. Yieldup Intern. Corp.*, 349 F.3d 1333, 1342 (Fed. Cir. 2003). Moreover, as the Supreme Court recently stated, "there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *KSR Int'l v. Teleflex Inc.*, 127 S. Ct. 1727, 1741 (2007).

Because none of the art of record, whether considered independently or in combination, teach or suggest the claimed method for providing power wherein the p-type or the n-type thermoelements have L/A ratios from about 500 cm^{-1} to about 10,000 cm^{-1}, a *prima facie* case of obviousness has not been presented.

[1] Although the amendment of claim 1 has rendered moot the Examiner's assertion that Böttner teaches co-sputtering of thin films of n-type and p-type bismuth/antimony telluride compounds as thermoelectric material, we note that the Examiner's assertion is incorrect. Böttner does not teach how to make n- and p- type materials. Böttner indicates that elemental targets of Bi, Sb, and Te were used to deposit n-Bi_2Te_3 and p-$(Bi, Sb)_2Te_3$ materials and refers to annealing materials to adjust properties. Böttner does not, however, teach how one actually achieves such deposits. For example, Böttner does not disclose the following information (necessary to teach how to make the deposits): (1) power levels necessary to be applied to targets or, equivalently, the magnitude of the atomic flux to be emitted from each target; (2) substrate temperatures needed during deposition; (3) temperatures for annealing of films necessary to adjust the film properties; and (4) parameters and methods used for growth of p-$(Bi,Sb)_2Te_3$ materials. (Discussed below in relation to claim 37.)

B. Because the L/A ratio is result effective, the lack of a teaching or suggestion in the prior art of the recited L/A ratio is not "excused" based on an allegation that the L/A ratio is a mere dimension limitation.

The Examiner has asserted that the fact that the prior art does not teach or suggest the recited L/A ratios is irrelevant because the criticality of the L/A ratio has not been shown with evidence (Office action p. 13). Applicants' specification indicates how the L/A ratio is vital to the performance of the thermoelectric device/method. Specifically, Applicants determined through testing that a key parameter affecting the power produced by the thermoelements is the length-to-area (L/A) ratio of the individual thermoelements. Applicants provide particular L/A ratios so to achieve desired power outputs at large enough voltages to be directly applicable to intended particular devices needing power, without having to provide voltage amplification. Put another way, the L/A ratios and dimensionalities taught by Applicants critically govern the difference between acceptable and non-acceptable output of a desired method/device.

C. Because the prior art did not recognize that the L/A ratio is a result-effective variable, Applicants' determination of desirable ranges of the L/A ratio cannot be dismissed as obvious, routine experimentation. MPEP at § 2144.05 II B.

As stated above, the art of record does not teach or suggest the recited L/A ratios. Because the prior art did not recognize that the L/A ratio is a result-effective variable, it is improper for the Examiner to dismiss the recited limitation as being obvious as a mere optimization of dimensions based on routine experimentation. The law, as cited in MPEP § 2144.05 II B, has made it clear that to "excuse" such limitations as mere optimization of dimensions or ranges, the prior art must have recognized that the dimensions or ranges were result-effective variables. Put another way, recognition of the L/A ratio functionality is essential to a finding of obviousness of conducting experiments to determine such desirable ratios and to the resulting claimed processes reciting such. The prior art not only does not teach or suggest the claimed L/A ratios, but also fails to even recognized the result-effective aspect of the L/A ratios; accordingly, it cannot reasonably be held that the non-disclosure of the recited L/A ratio ranges in the prior art is irrelevant by asserting it was obvious experimentation for optimization or other such assertions. Such a conclusion would be both improper and incorrect.[2]

[2] In addition, the Examiner's reliance on a finding of obviousness based on alleged optimization of a dimension without inquiring as to whether such variable functionality was even recognized in the prior art, ignores the last sentence of § 103(a) – "Patentability shall not be negatived by the manner in which the invention was made."

D. Even if a *prima facie* case of obviousness were presented, the obviousness rejection is rebutted in the § 1.132 Declaration showing that the L/A ratio range is critical, producing unexpected results.

The L/A ratios are critical parameters of the devices utilized in the claimed apparatus, as is disclosed in the present application. The criticality of the L/A ratio was not known in the prior art but instead discovered by Applicants, whose testing produced unexpected superior results for the recited power producing method claims. Please see the Second § 1.132 Declaration of John DeSteese (filed herewith) supporting this statement. Neither Migowski nor Böttner, nor any other reference of record, whether considered independently or in combination, teach or suggest such L/A ratios or even recognize the result effective aspect of the L/A ratio. The showing of the unexpected results achieved through Applicants' discovery of the criticality of the L/A ratio rebuts any presented *prima facie* case of obviousness. The Second § 1.132 Declaration of John DeSteese includes evidence of criticality of the L/A ratio over the entire claimed range, illustrating L/A ratios and results for 781 cm^{-1} to 10,000 cm^{-1}.

For the myriad of reasons set forth above, claim 1 is allowable over the art of record.

Claim 3: As amended, claim 3 recites the power source of claim 1 wherein the p-type and the n-type thermoelements comprise Bi_xTe_y, Sb_xTe_y, and Bi_xSe_y, wherein x is about 2 and y is about 3. Support for this amendment can be found in originally filed claim 30 and at p. 10, l. 6 of the present specification.

None of the references of record, whether considered individually or in combination, teach or suggest having tertiary p-type and n-type thermoelements comprising all of Bi_xTe_y, Sb_xTe_y, and Bi_xSe_y. Accordingly, in addition to the reasons set forth above for claim 1, claim 3 is allowable for this reason as well.

Claim 5: As amended, claim 5 recites the thermoelectric power source of claim 1 wherein the thermoelectric power source has a power output of from 50 μW to 1 W. Support for this amendment can be found at p. 4, lines 7-10 and p. 8, lines 3 – 11 of the present application.

The Migowski disclosure does not teach or suggest a TE power source capable of producing from 50 microwatts to 1 W of electrical power. In fact, the Migowski reference indicates that its

device produces a power of 11 microwatts. (Page 4, second full paragraph beginning with "Layer thickness ...".) Böttner fails to make up for the deficiency of Migowski. Accordingly, in addition to the reasons set forth above for claim 1, claim 5 is allowable for this reason as well.

Claims 6-10 and 12-15 are allowable for the reasons set forth above in relation to claim 1 and for each claim's unique and non-obvious combination of features.

Claim 17: As amended, claim 17 recites the thermoelectric power source of claim 1 wherein the n-type or the p-type thermoelements-comprise Sb_xTe_y, Bi_xTe_y and Sb_xTe_y, or Sb_xTe_y and Bi_xSe_y.

None of the references of record, whether considered individually or in combination, teach or suggest tertiary or binary p-type and n-type thermoelements comprising all of Sb_xTe_y, Bi_xTe_y and Sb_xTe_y, or both of Sb_xTe_y and Bi_xSe_y. Accordingly, in addition to the reasons set forth above for claim 1, claim 17 is allowable for this reason as well.

Claim 18 is allowable for the same basic reasons as set forth for both claim 1 and claim 17.

Claim 37: Amended claim 37 recites, in part, a thermoelectric power source comprising a thermoelectric couple comprising alternating thin film p-type and n-type thermoelements, wherein the p-type or the n-type thermoelements comprise Sb_xTe_y or Bi_xSe_y wherein x is about 2 and y is about 3. The art of record does not teach or suggest such thin films. Clearly there is no teaching or enablement of such in the Migowski reference. And, contrary to the Examiner's assertions, Böttner does not make up for the deficiencies of Migowski.

Böttner fails to teach (enable) the making of Bi/Sb/Te thin films. Böttner states that both n-Bi_2Te_3 and p-$(Bi,Sb)_2Te_3$ materials were grown by co-sputtering from 6" elemental targets -- that is, Bi, Sb and Te targets. Although the potential use of selenium as a component is mentioned, films were not actually deposited that incorporated Se. Furthermore, Böttner refers to "annealing" materials to adjust thermoelectric properties. Figure 10a describes Seebeck coefficient of films versus Te content in atomic percent and there is data presented for cold sputtered and hot sputtered Bi_2Te_3, and annealed materials. Although not specifically discussed in Böttner, the Examiner apparently assumes that the plotted results are for films grown by co-sputtering from Bi and Te targets. However, Böttner does not teach one of ordinary skill in the art how to accomplish the results plotted in Figure 10a. No

information is provided for the necessary values of power applied to the Bi and Te targets, and no detailed information is provided concerning substrate temperatures used during sputtering or as to annealing temperatures to achieve the listed thermoelectric properties. Thus, Böttner does not enable deposition and annealing of the recited thin film n-type material.

Furthermore, Böttner fails to teach (enable) the deposition of the recited p-type material. The first line in the Böttner reference section "Growth of Thermoelectric materials" (page 514) states "n-Bi2Te3 and p-(Bi,Sb)2Te3 materials were grown by co-sputtering from 6" elemental targets. In the section entitled "Structural Properties" (bottom of page 514), Böttner indicates EDX analysis was used to verify the metal/chalcogen ratio for all grown layers and to control the Bi/Sb ratio of the p-type material. But, Böttner has not taught one of ordinary skill in the art <u>how</u> to deposit the p-type material. Although the reference is quite vague and ambiguous, based on earlier statements in the reference, one might assume that elemental targets of Bi and Sb were used to grow films with particular Bi/Sb ratios (although this is not clear in the reference). However, there is no teaching as to <u>how</u> one achieves a p-type material that has Bi, Sb and Te components. As such, Böttner fails to teach how to achieve deposition of such p-type films. Figure 11a describes data for the Seebeck coefficient of p-type materials versus Te content and the films are referred to as (Bi,Sb,Te) materials with data provided for such films, but there is no explanation whatsoever as to how to grow materials with such properties.

Accordingly, the Böttner reference is non-enabling for this reason as well. As the Examiner knows, a prior art reference must be enabling – must teach how to make that compound, composition or method <u>for which the reference is cited as teaching to be citable prior art</u>.

For the reasons set forth above, claim 37 is allowable over the art of record. **Claims 38 and 39** are allowable for the same reasons as claim 37 and based on each claim's unique and non-obvious combination of features.

The Examiner has rejected claims 11 and 16 under 35 U.S.C. § 103(a) as allegedly being unpatentable over Migowski (WO 89/07836) in view of Böttner and Bass. Applicants traverse.

Because Böttner and Bass fail to make up for the deficiencies of claim 1 as discussed above, claims 11 and 16 are allowable for the same reasons. In addition, without reiterating the arguments herein, the Applicant's again assert that the combination of Bass with Migowski is improper for the reasons set forth in the prior filed Responses.

Request for Interview

If any issues remain, the Examiner is requested to please contact the undersigned attorney prior to issuance of an Advisory Action or another Office Action in order to arrange a telephonic interview. It is believed that a brief discussion of the merits of the present application will expedite prosecution.

Respectfully submitted,

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